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In-module chemical modification and assessment of polyethersulfone capillary ultrafiltration membranes

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Membrane technologies/systems have revolutionised the water treatment industry in alleviating the plight of lack of access to clean water worldwide [1]. This is as a result of their potential in providing an absolute barrier for bacteria, viruses and other water-borne diseases which are alleged to be the leading causes of childhood morbidity and mortality [2]. The drawback associated with the membrane applications in water treatment is the decreasing water permeation rate with time as a result of fouling caused by rejected substances forming a cake on the membrane surface. Research is currently being done to reduce the fouling in membranes through chemical modification by varying membrane surface hydrophilicity and surface charge. This study explores the surface modification of the commercial capillary ultrafiltration (CUF) membranes by introducing hydrophilic molecules on the surface as a fouling reduction strategy for water treatment applications. The poly(sodium-4-styrene sulfonate) (PSS) and potassium persulfate and potassium bisulfite couple were used as the hydrophilic monomers and the initiators respectively, to chemically modify the commercial PES CUF membranes. The modification was carried out by permeating the mixture of the hydrophilic polymer and the initiators through the sealed CUF membrane module for 24 h. The effect of PSS content on the properties of the modified membranes was investigated. Both the unmodified and the modified CUF membranes were assessed by the FTIR, contact angle, AFM and HRSEM.

The FTIR analysis confirmed the successful grafting of the PSS on the CUF surface as evidenced by the appearance of the band at 1040 cm^{-1} observed in the modified membranes. This band is attributed to symmetric stretching of SO_3^- of the PSS unit. On comparison to the pristine CUF, the hydrophilicity of the modified CUF membranes improved as the PSS increased up to 6000 ppm. The lower contact angle in the PSS modified CUF membranes indicated that the surface character was now more hydrophilic which is expected to affect the protein fouling profile as well as the water flux (Figure 1). The AFM results revealed significant changes in surface morphology as compared to the pristine CUF. The modified membranes displayed significant increase in the density of nodules as expected confirming that the PSS molecules are now anchored on the membrane surface. Furthermore, the surface roughness increased with an increasing content of the PSS. This is as a result of the surface enrichment of the PSS due to only partially miscibility between CUF and the PSS. The cross-sectional SEM analysis showed no meaningful morphological changes of the modified CUF membranes as compared to the pristine CUF, however, the analysis on the membrane surface showed that more polymer molecules are anchored on the modified CUF membranes.

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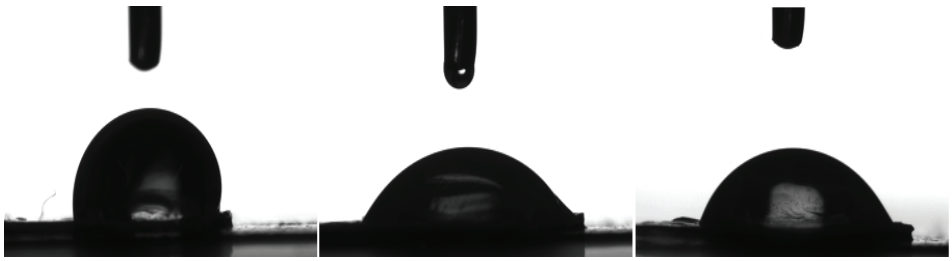

***Figure 1**: Drop shapes of water droplet on the washed membranes (**A**), CUF modified with 4000 ppm PSS (**B**) and CUF modified with 6000 ppm PSS (**C**)*

The capillary ultrafiltration membranes were chemically modified using PSS in the presence of the initiators. FTIR confirmed the successful grafting of the PSS onto the CUF membrane surface. The AFM analysis indicated that the morphology of the grafted membranes changed significantly as compared to the virgin CUF with an increased roughness. The hydrophilicity of the modified membranes increased compared to that of pristine CUF which bodes well for improving fouling characteristics. The process of modifying the membranes did not lead to visible changes in the membrane structure with no evidence of pore collapse observed (SEM analysis) indicating that the method can be used for in-module membrane modification to modify polymeric membrane surfaces.

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